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NTSB Investigation Hearing

Battery/Battery Charger Sub-system

Panel 2 – Design and Development

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TAES' experience in civil aviation electrical systems

Thales Avionics Electrical Systems (TAES) is a part of the Thales group of companies. Thales is one of the world's largest aerospace contractors.

TAES has more than 60 years of experience in aerospace.

TAES is supplier partner in design development, manufacturing & support for :

- ✓ Electrical Power Generation
- ✓ Electrical Power Conversion

TAES is on board the following aircraft:

BOEING · Gulfstream · AIRBUS · ATR · eurocopter · DASSAULT FALCON · BOMBARDIER · DASSAULT AVIATION · 中国航空工业集团公司

AIR TRANSPORT

Airbus
- A300
- A310
- A330
- A340
- A350
- A380

Boeing
- 787

REGIONAL AIRCRAFT

Antonov
- AN 140/148

Bombardier Aerospace
- Dash 8 Q400
- CRJ 700/900

Catic
- Y12E

Fairchild Dornier
- DO 328 Jet

Regional Transport Aircraft
- ATR 42/72

SAAB
- SAAB 340/2000

BUSINESS JETS

Bombardier Aerospace
- Challenger 300
- Global Express

Dassault Aviation
- Falcon 50 EX
- Falcon 900 EX
- Falcon 2000 EX
- Falcon F7X

Embraer
- Legacy 450
- Legacy 500

Gulfstream
- G200
- G280

Socata
- TBM 700/850

HELICOPTERS

EADS Eurocopter
- Dauphin
- Colibri
- Ecureuil

Kamov
- Ka 226

AVIC
- AC 313

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TAES on board Boeing 787

TAES was selected by Boeing in 2004 as supplier of the following components for the Power Conversion System (PCS)

Cargo area

GATU
Galley Auto Transformer Unit

Forward E/E Bay

Lithium-Ion Main Battery

BCU
Battery Charger Unit

Battery Diode Module (**BDM**)

AFT E/E Bay

BCU
Battery Charger Unit

Lithium-Ion APU Battery

SPU
Start Power Unit

ATRU x 4
Auto Transformer Rectifier Units

Power Conversion Panels

ATU
Auto Transformer Unit

EBPSU x 2
E-Brake Power Supply Units

MTRU x 2
Multitap Transformer Rectifier Units

- ✓ **PCP, MTRU, GATU, ATU, EBPSU, ATRU, BDM designed by TAES**
- ✓ **Battery designed by GS YUASA**
- ✓ **Charger (BCU) & Start Power Unit (SPU) designed by Securaplane**

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Battery - Background

Main Dates

- ✓ **RFP response: Sept 2003**
  - ✓ Baseline : Ni-Cd
  - ✓ Growth Potential : Li-Ion
- ✓ **"Trade study" request from Boeing: May 2004**
- ✓ **Collaborative Battery Supplier selection : Sept 2004**
- ✓ **Authorization To Proceed w/ Li-Ion: Nov 2004**
  - ✓ Baseline : Li-Ion
  - ✓ Back-up : Ni-Cd
- ✓ **Extensive and lengthy testing conducted : 2005-2011**
- ✓ **Battery Qualification approved by Boeing : Sep 2010**
- ✓ **Approval of the Production Standard by Boeing : July 2011**

Lithium-ion technology complied with Boeing's requirements for optimized power & energy density, dimension & operating voltage range.

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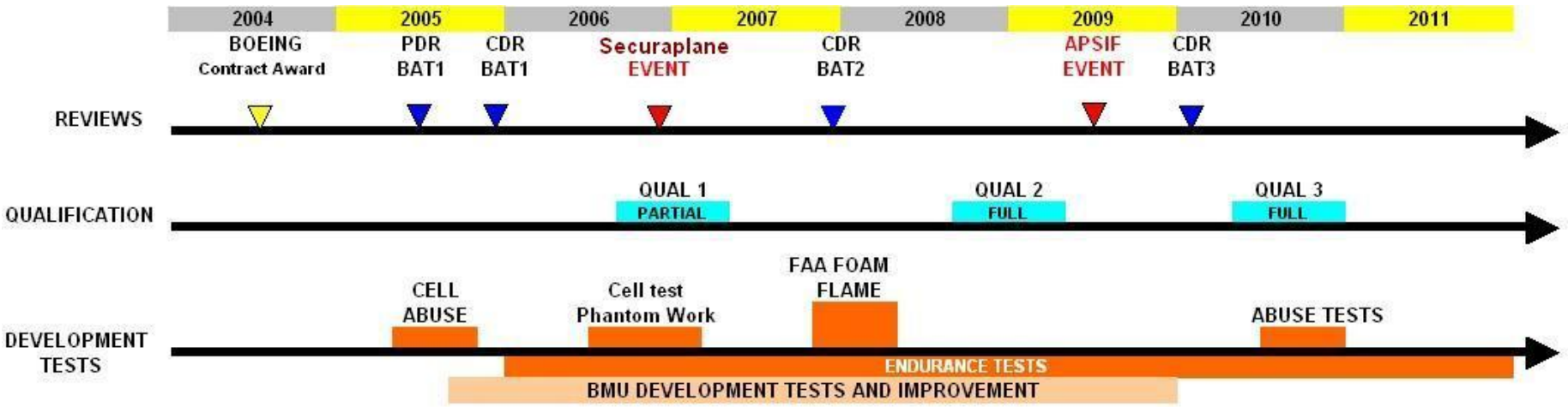
Battery Engineering Process & Qualification Testing Timeline

Development and Qualification performed according to Boeing and Thales rigorous Processes



3 versions of Battery unit were utilized during the development phase:

- ✓ **Battery baseline Lithium Cobalt with Battery Management Unit (BMU) 1 & 2.**
- ✓ **Battery baseline + Contactor + BMU 3 after Securaplane event.**
- ✓ **Battery baseline + Contactor + BMU 3 + BMU 4 + sealed casing and added Battery Diode Module after APSIF event.**

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Battery Charger Unit - Background

Main Dates

- ✓ RFP response: Sept 2003
- ✓ Collaborative Battery Charger Supplier selection : Jan 2005
- ✓ Specification Review : Nov 2005
- ✓ Extensive and lengthy testing conducted : 2005-2011
- ✓ Battery Charger Qualification approved by Boeing : Sep 2010
- ✓ Approval of the Production Standard by Boeing : July 2011

The Charger unit is an electronic DC/DC converter that automatically charges, protects and provides Battery and Battery Charger status to A/C system.

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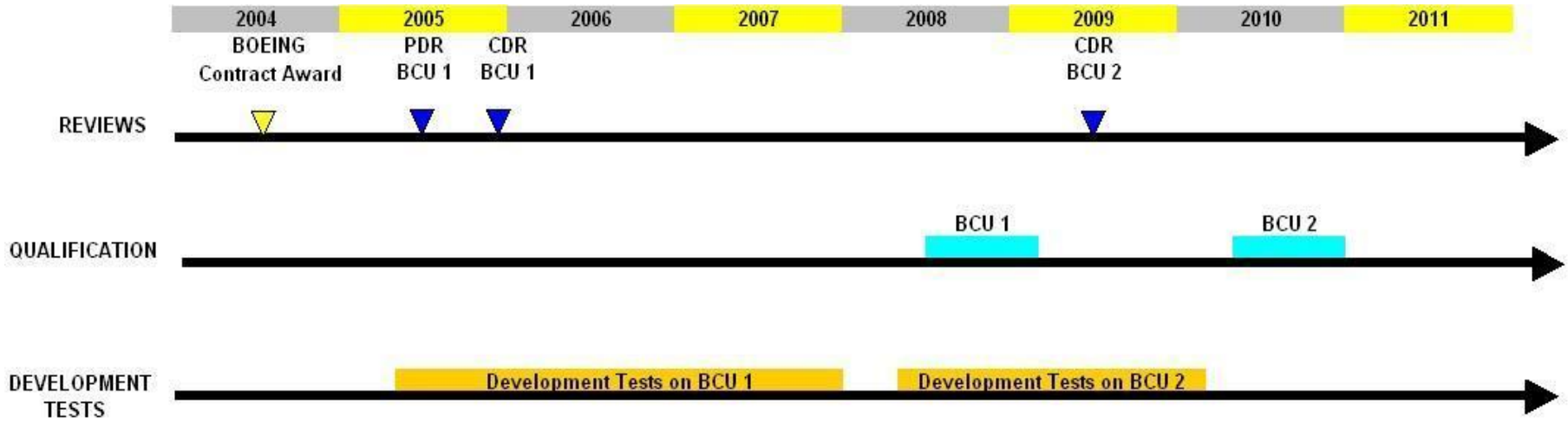
Battery Charger Engineering and Qualification Testing Timeline

Development and Qualification performed according to Boeing and Thales rigorous Processes



2 Design Iterations of Charger Unit were utilized during the development phase.

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Role & Responsibility for Boeing 787 PCS, Battery & Charger

TAES is responsible for Engineering design of the following components: PCP, ATU, MTRU, EBPSU, BDM, ATRU, GATU

- ✓ TAES responds to Boeing specification of each component
- ✓ Delivers qualification files for each component to Boeing to support the Certification

GS YUASA is responsible for Engineering design of Battery Lithium-ion

- ✓ GS YUASA responds to specification as provided by TAES & develops the Battery
- ✓ Delivers to TAES qualification files for Battery

Securaplane is responsible for Engineering design of BCU and SPU

- ✓ Securaplane responds to specification as provided by TAES & develops the BCU and SPU
- ✓ Delivers to TAES qualification files for BCU and SPU

Design and Development were performed according to Thales and Boeing Processes as part of Boeing's application for Certification to FAA/EASA

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Summary

- ✓ Thales Avionics Electrical Systems partnered from the beginning with Boeing in developing a battery sub-system to meet the needs of the first commercial “More Electric Aircraft”
- ✓ Iterative and Collaborative Design Process with GS YUASA, Securaplane and Boeing
- ✓ It was Lithium-ion technology alone that was able to meet the needs of Boeing’s 787 mission
- ✓ Every step of the Design Process was safety driven and performed with utmost care

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